MODEL 200B

DC VTVM

AND ACCESSORIES

KEITHLEY INSTRUMENTS, INC.

CLEVELAND, OHIO

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SECTION I INTRODUCTION

The Keithley Model 200B VTVM is a battery operated vacuum tube voltmeter with an input impedance of greater than 10^{14} ohms shunted by 8 mmf, and input grid current less than 5×10^{-14} ampere. It is therefore, an electrometer and features an extremely high voltage sensitivity and wide measuring range. Output terminals are available which allow the instruments to be used as a unity-gain, high impedance preamplifier from dc to 300 cps. A few precision accessories equip the Model 200B for a wide range of measurements, as described in the USES section of this manual. Briefly, the instrument can be used to measure the following within the rnages indicated:

Voltage	From 8 millivolts to 20 volts full scale.
Current	From 10^{-3} to less than 10^{-12} amperes full scale.
Resistance	Above 10^{14} ohms full scale.
Capacitance	Down to 10 mmf.

CONTROLS AND TERMINALS

The input terminals of the Model 200B are located at the top of the instrument. The HI terminal is surrounded by a ground ring. The ground terminal and ring are attached to the case of the instrument. 200 C has a separate GND.

The operating controls are as follows:

Meter reverse and battery test. Located at the upper left of the panel, this control selects meter polarity so that either positive or negative potentials on the HI terminal produce up-scale reading. It also connects the meter for testing the instrument's batteries.

Balance: Located at upper middle of panel, this control is adjusted to give constant zero from range to range by balancing the two input tubes.

On-Fil-Off: Located at the upper right of the panel, this control turns the instrument on and off. The intermediate FIL position allows the filament voltage to be applied and the filaments to reach operating temperature before plate voltage is applied. This avoids any chance of unstabilizing the tubes by applying plate voltage too quickly.

Range switch: Located at the lower left of the panel. This switch selects the voltage ranges of the meter. When the meter polarity switch is in the Battery Test position the Range Switch connects the panel meter and a suitable resistor across each battery to be tested.

Zero: Located at the lower right of the panel, this control is used to zero the meter pointed at either the left edge or the center of the meter.

Input Switch: Located on the top of the instrument next to the HI terminal. This is used when setting the input zero. When the Input Switch is operated, the input tube grid is grounded; but 22 megohms is still in series with the HI terminal to the switch, preventing large currents flowing from a low impedance source.

SECTION II

SPECIFICATIONS AND DESCRIPTION

Ranges: Eight voltage ranges of .008; .02; .08; .2; .8; 2; 8; and 20 volts full scale are provided. The meter polarity switch allows positive or negative voltages to be read.

Input Impedance: The input circuit has an impedance of greater than 10^{14} ohms in parallel with a capacitance of about 8 mmf.

Grid Current: The grid current is less than 5×10^{-14} ampere on all ranges. Therefore, with the HI terminal floating and shielded, the needle will drift across the scale on the 0.8 volt range in about one minute. The time will be proportionately shorter for the more sensitive ranges and longer for the less sensitive ranges. It should be noted that the grid current will also flow through the circuit being tested.

Zero Drift with the input terminals shorted is within one millivolt per hour after a 2 hour stabilization period. Before making measurements on the most sensitive ranges, a warm-up period of about 30 minutes is desirable.

Calibration Accuracy: The calibration accuracy is within 2% of full scale on all ranges. This accuracy is maintained throughout the life of the instrument by using substantial negative feed-back and 0.25% wire-wound resistors in the critical circuits.

Output Terminals permit the connection of recording or indicating equipment. The voltage gain from the input to the output is approximately unity. The terminals are in parallel with the feed-back resistor; therefore some care must be used when employing the 200B as a preamplifier if the meter calibration is not to be affected. In general, the output will drive vacuum tube amplifier inputs and sensitive recorders, such as the Varian and Speedomax, which incorporate an amplifier. Detailed instructions are contained in Section III.

Amplifier Response: The frequency response extends to about 300 cps. The maximum undistorted voltage output from the output terminals varies with each range, being approximately equal (peak to peak) to the full-scale meter sensitivity of any particular range. Detailed specifications are listed in Section III.

Amplifier Noise: Noise above about 5 cps referred to the input is less than 100 microvolts.

Protective Features: Overload protection for the first-stage tube is provided by a 22-megohm resistor in series with the first-stage grid, which prevents a large grid current from flowing when excessive positive potentials are applied to the input. When the input shorting switch is depressed, the 22 megohms is in series with the HI terminal, limiting possible current flow from a low-impedance source. Tube saturation current is well within meter limits. The ON-FIL-OFF switch short circuits the meter in the OFF position, preventing meter damage in transit.

Circuit Description:

DR 10759C enclosed at the back of this booklet, is the circuit schematic diagram of the Model 200B.

Tubes V1 and V2 are type 5886 electrometer tubes operated as pentodes in a balanced circuit. Compensation for difference in static characteristics between V1 and V2 is affected by R112, the BALANCE control. By means of this control, the bias of V2 is adjusted to make the meter zero point on the most sensitive range agree with the meter zero point on the least sensitive range.

The input tubes are followed by V3 and V4, which are type 6418 pentodes, operating as a balanced second stage. Together these stages have a voltage gain of about 1600 and by virtue of their balanced arrangement, the drift at the input does not exceed 1 millivolt per hour after warm-up. All plate and filament supplies to these two stages are floating. The "ground" of this floating amplifier is connected to the filament of V5, which is a 6418 operated as a triode cathode follower.

The grid of V5 receives its signal from the plate of V3 via a $22\frac{1}{2}$ volt dropping battery. Since V5 operates as a cathode follower, it drives the floating amplifier at essentially the V5 filament potential. The signal is applied between the input lead and case ground; and since V5 also has its batteries attached to ground, this means that all the electrodes of V1 are driven at essentially the same instantaneous potential as the signal to be measured. This circuit arrangement insures constant grid current on all ranges. Further, since the filament of the input tube follows the input grid, 100% negative feedback is applied around the circuit, insuring gain stability.

The meter measures the current that V5 must pass in order to bring its filament to the potential of the input signal. Resistors R208 and R214 in parallel with R225 are so chosen that the plate current of V5 must change by 50 microamperes for the specified full scale input signal. Battery B6, R202, and R204 form a buck-out circuit which cancels the quiescent plate current of V5. R202 is the ZERO control. Its variation changes the buckout current, allowing the user to place the pointer at left or center meter zero.

R216 is the meter trim control, to compensate for meter inaccuracy. R202, the zero control, will also affect meter accuracy somewhat. R216 is set so that the calibration is most accurate with the pointer zeroed at the left edge. In no case, however, will instrument accuracy be less than 2%.

If the need should arise, it is possible to reduce the full scale meter reading below 8 mv by loading the output terminals. With the range switch on the 20 volt position and a resistance of 32 ohms across the output terminals, the full scale sensitivity will be about 2 millivolts. Of course, the zero instability will be more apparent with this higher sensitivity.

In the event that BALANCE is not reached at the extreme of BALANCE control travel, the COARSE BALANCE switch, SW 5, should be rotated one position.

SECTION III: OPERATION

This section applies primarily to use of the Electrometer for indicating and recording potentials within its scale ranges. For a detailed discussion of measuring higher potentials, current, resistance, capacitance and electrostatic fields, see the sections on USES AND ACCESSORIES.

To place in operation: Turn the range switch to the 20 volt position and the Meter Polarity to +; short the input with a strap or by depressing the input switch button; turn OFF-FIL-ON switch to FIL. After waiting 10 seconds, turn switch to ON. With ZERO control, zero the pointer at the left or the center of the meter. Next, turn to the 8 mv range and bring the needle to zero again with the BALANCE control. The zero setting now will not vary from range to range. When resetting the instrument to compensate for first-stage drift, always use the BALANCE control, never ZERO control. The ZERO control is used to set the pointer initially, and not in making subsequent corrections for drift; otherwise the zeroes will not line up on all ranges.

To check the balance adjustment: Set the RANGE at 20 volts. On this range the BALANCE control has negligible effect on the meter reading. Short the input terminals and set the ZERO control to give the desired meter zero. Then set the RANGE to the 8 mv range and using the BALANCE control, set the meter to the same zero point.

Shielding: If the 200B is used in a high impedance circuit, careful shielding of the input leads and test circuit is mandatory. In some cases, where lower impedances are employed, shielding may be avoided if leads are kept as short as possible.

If it is necessary to enclose the high terminal and the high impedance circuit with electrostatic shielding, it is recommended that teflon or polyethelene cable be employed in conjunction with the input connector.

Speed of Response of the electrometer in a high impedance circuit is determined by: a) the response of the electrometer circuitry, viz: time required for the meter to deflect when a voltage is applied to the input terminals - this is approximately one second; and b) the time for the effective internal impedance of the signal source to charge up the input capacitance of the electrometer plus the capacitance of any associated wiring connecting the signal source to the electrometer - this can be less than a second or up to several thousand seconds in extreme cases.

Precautions: In making careful measurements, the zero drift of the electrometer should be checked. In general, on the less sensitive ranges the drift will be negligible after a few minutes warm-up time. On range steps of 80 millivolts and below, the zero should be checked from time to time.

Grid Current: The grid current is the limiting factor when using an electrometer with a high megohm resistor to measure current. Signals less

than the grid current cannot usually be measured satisfactorily.

When using a 10^{12} ohm resistor with the Model 200B to measure current, the 2 volt range gives 2×10^{-12} ampere full-scale; on this, the 5×10^{-14} ampere grid current is only 2% of full scale. If, however, the 200B had been set to the 0.008 volt range to give 8×10^{-15} ampere full-scale, the grid current of 5×10^{-14} ampere would drive the meter needle past full-scale. This combination, therefore, is obviously not usable. Similar unusable combinations should also be avoided.

Grid Drift Current: If the HI terminal is left open and shielded, the current flowing in the grid circuit will charge the input capacity of the instrument. Knowing the input capacitance and the time it takes to charge to a known voltage is a measure of the grid current of the instrument.

Due to the physics of the vacuum tube, the grid circuit behaves as a constant current generator. Thus if the charge on a capacitor is given by

$$Q = CV \qquad (3)$$

Where Q is the charge, C the capacity of the input, and V is the input voltage, the current (I) flowing in the input is the time derivative of (3) or

$$I = C\, dV/dt \qquad (4)$$

Now if I is a constant, dV/dt must also be a constant. Thus (4) is written

$$I = C\, V/t \qquad (5)$$

with no loss of exactness.

To compute the grid current of the electrometer, take C to equal about 8 micromicrofarads and determine the time necessary for the electrometer, starting from zero, to read some fraction of full scale. In a practical circuit, it is well to limit voltage to about 10% of full scale since grid current can change if the operating point of the electrometer tube is shifted too much.

Assume, for example, operation on the 2 volt range. Short the input and zero the meter; now release the shorting button. Timing the rise of the pointer, it is found that it takes 100 seconds for the pointer to travel 0.2 volts. The grid current then is:

$$I = 8 \times 10^{-12} \times \frac{0.2}{100} = 1.6 \times 10^{-14} \text{ amperes.}$$

Measurement of Grid Current by Resistance: Place a resistance of between 10^{10} and 10^{12} ohms across the input terminals. Shield carefully. Short the input, zero the pointer, and then allow about a minute after releasing the shorting switch for the pointer to come to rest. The grid current is equal to the voltage read on the electrometer divided by the resistance used. The grid current should be in a positive direction. In some cases, where an instrument has not been used for a considerable length of time, a large negative grid current will be seen. This will usually disappear after about an hour's operation.

Recording

The Model 200B is provided with output terminals so that it may be employed as a unity gain preamplifier. The output terminals are connected in parallel with the calibrating resistor for a particular range. Therefore, if, while recording, meter calibration accuracy is important, the permissible load resistor must be greater than 100 times the value of the internal calibrating resistor. The following table lists the value of the internal calibrating resistor versus range. If calibration accuracy of the meter is not important, the output may be loaded with any value of resistance down to about 150 ohms, and the instrument will function as a unity gain impedance transformer. (When thus deliberately upsetting the calibration accuracy, leave the range switch at the 20 volt range.) The actual meter sensitivity with external load is found by extrapolation from the table. Compute the value of the parallel combination of 450K and the value of the load resistance. This is now the value of the calibrating resistance and may be compared with the value given in the table for the actual full-scale sensitivities used in the instrument. The permissible full scale input (peak-to-peak) with any particular loading is approximately twice the full scale sensitivity.

The frequency response will be affected by the loading, since this affects the feedback in the electrometer. If the full scale meter range is 0.02 volt or higher the amplifier response will be within 3 db to at least 300 cps.

MAXIMUM OUTPUT LOADING

Range (Full Scale Sens.)	Internal Cal. Resistance (Approx.)	Max. Loading for less than 2% Calibration error.	Max Peak-to-Peak Output
0.008 volts	150 ohms	15K ohms	0.016 volts
0.02	400	40K	0.04
0.08	1.5K	150K	0.16
0.20	4K	400K	0.40
0.80	20K	2 Meg	1.60
2.0	40K	4 Meg	4.0
8.0	250K	25 Meg	16.0
20.0	450K	45 Meg	40.0

Correction for Input Capacity: It must be remembered that the internal capacitance of the Electrometer shunts any external capacitance connected to the input terminals. The internal capacity is approximately 6 mmf and corrections must be made if this is appreciable compared to an external capacitor whose voltage is being measured.

SECTION IV MAINTENANCE

WARRANTY: Keithley Instruments warrants its products against all manufacturing defects except tubes, transistors, batteries and fuses. Free factory service is furnished the original purchaser for one year. Thereafter, factory service is provided at nominal cost.

The Keithley Model 200B electrometer has been designed to give long, trouble free service. High quality componenets have been used throughout, and the circuits are stabilized by a substantial amount of negative feedback.

The insulators for the high impedance conductors are made of teflon, and should retain their excellent insulation properties even in humid weather. Dust may accumulate on the HI terminal insulator and reduce the input impedance. The HI terminal may be cleaned with a lint-free cloth.

Pilot Light The neon bulb on the front panel together with R223 and C202 form a relaxation oscillator. This arrangement allows an effective visual indication when the instrument is turned on while requiring only about 5 microamperes of current. This has negligible effect on battery life.

The neon bulb should have indefinite life under normal conditions. It is an integral part of the holder assembly; and if it must be changed, the connecting wires must be unsoldered and the assembly unbolted from the panel. Replace with a Type 1A-1369 manufactured by the Eldema Corp., El Monte, California, or its equivalent.

Battery Life All the batteries in the Model 200B are relatively lightly loaded, and all should give satisfactory service for more than 500 hours. If they are used longer, the zero drift and calibration accuracy may be affected. Very old batteries often leak corrosive and conductive fluids which harm the battery holder and upset the instrument's performance.

All the batteries except one can be tested by using the panel meter and the Range Switch, as outlined below. The battery which is not tested is B9, an interstage coupling; it is in a high impedance circuit and supplies only a fraction of a microampere. It should give satisfactory service for more than a year.

B4 and B5 are also lightly loaded. For the most reliable service, however, it is recommended that all the batteries be replaced when the voltage of one battery has gone below the recommended limit.

As has been described previously, substantial negative feedback is used in the circuit, and the calibration accuracy is not affected more than about 0.5% by the changes in battery potentials from when new batteries are installed until they are all at their lower voltage limits.

Battery Testing: To test batteries, turn Meter Polarity switch to the BAT TEST position. The Range Switch will then select the battery being tested as listed in the table below. If any battery reads less than 1.1 on the 2.0 meter scale, all batteries should be replaced. Each battery is identified on the battery board.

BATTERY TEST POSITIONS

Range Step	Battery Tested
0.008 volts	B1
0.02	B2
0.08	B3
0.2	B4
0.8	B5
2.0	B6
8.0	B7
20.0	B8

Battery Replacement: To replace any of the batteries, the instrument should be removed from the case by unscrewing the three screws on each side of the case. The two screws holding the battery cover plate are then removed and the battery cover is lifted off. Note that the plus end of each battery faces toward the edge of the battery board.

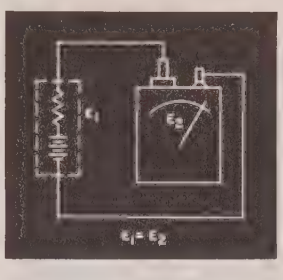
The interstage coupling battery, B9, is mounted on the chassis of the instrument.

Tube Replacement: The tubes required are two 5886 tubes and three 6418. The 5886 tubes are enclosed in steel tubing to provide magnetic shielding. The 5886 tubes used are selected for matched characteristics, both dynamic and static. It is recommended that replacement tubes be obtained from Keithley Instruments. The tube used in the V1 position is labelled EV-5886-5 while that used in the V2 position is EV-5886-6. The EV-5886-5 generally has less grid current and thus could be used in either the V1 or V2 positions.

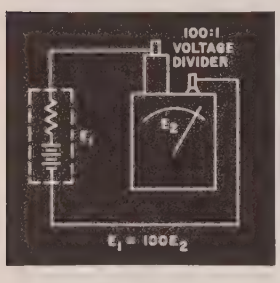
When installing a tube, first insert it in the holder. The tube should be oriented so that the red dot at one end of the press lines up with the red dot on the tube holder. Then give the individual leads one-half turn around the correct turret lug and solder them. Then trim the excess leads. Note that the plate and screen leads of V5 are connected to the same turret lug.

Typical applications are included on the next few pages to indicate the many measurements which the Electrometer and its accessories can make accurately and quickly. Full operating instructions for the various accessories are included in the last section of this book.

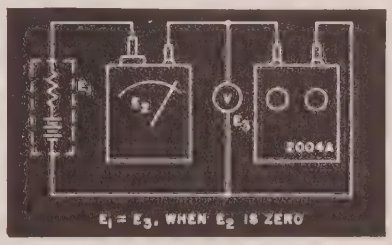
TYPICAL POTENTIAL MEASUREMENTS



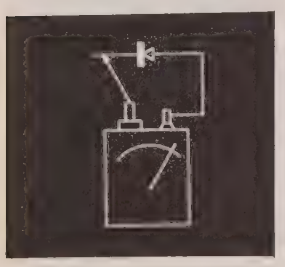
High resistance source within scale range. The high resistance or highly insulated terminal of the source is connected to the HI terminal of the Electrometer. The voltage is read directly, as described previously under OPERATION.



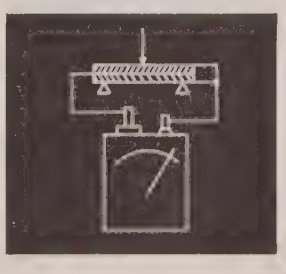
High resistance source, less than 20,000 volts. The Keithley Models 2006 and 2007 voltage dividers, (100:1 and 1000:1 ratios), convert the Electrometer into an extremely sensitive kilovoltmeter. 10^{12} ohms input resistance.



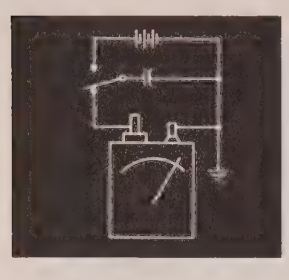
High resistance source, buckout method. An additional voltage source, such as the Keithley Model 2004A, is used to buck out most of the voltage, and the difference is read on the Electrometer. To avoid having excessive grid current flow through the unknown voltage source, the bucking voltage should be made more positive than the unknown voltage initially, then reduced until the difference can be read on the Electrometer. In this application the G terminal potential should not be made greater than about 50 volts from ground.



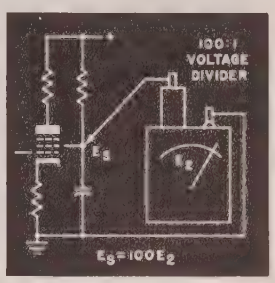
Surface contact potentials in semi-conductors or thermionic devices. The measurement is made by direct connection to the Electrometer.



Piezo-electric potentials. The electrode which provides the best shielding is connected to the G terminal. The other electrode is connected to the HI terminal. The electrometer reads the instantaneous voltage at the terminals of the crystal at low frequencies. The HI lead should be connected so that it does not move appreciably, particularly with crystals which have low internal capacitance.



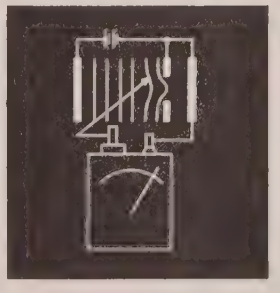
Potentials of charged capacitors. Connect HI to the high impedance terminal and G to the low impedance terminal, being careful not to discharge the capacitor through low resistance paths while making the connections. The voltage is read directly.



Vacuum Tube electrode potentials. The Electrometer is well suited to measuring electrode potentials in vacuum tube circuits, for only a very slight disturbance is caused by its connection, even in high resistance circuits. This is particularly desirable in dc amplifier work where small variations in potential can be greatly amplified, upsetting the normal operating conditions. The HI terminal is connected to the electrode, and G to ground or an auxiliary potential source depending on the magnitude of the voltage to be measured. As shown, a voltage divider is being used to permit measurement of the screen potential. An alternative method would be the buckout method described above.

The presence of a large ac signal at the electrode being measured can cause an erroneous reading, because of rectification in the electrometer tube grid circuit. The peak value of the ac signal should be held within the voltage of the scale range used, or a simple signal filter which passes only the dc component can be used.

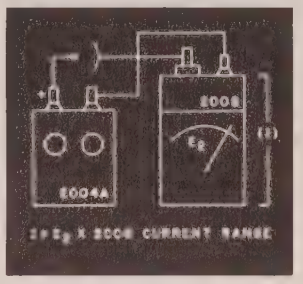
Static charge detection. The Electrometer is extremely sensitive to static charges, and can be used to make both qualitative and quantitive measurements. Addition of the Model 2005 Static Detector accessory, shown here, permits varying the sensitivity of the Electrometer, and confines the sensitivity to a small cone along the axis of the detector, permitting quick location of charged objects.



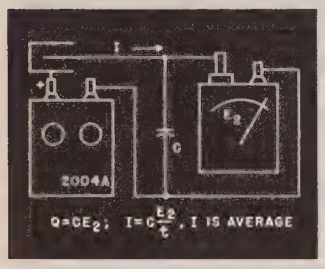
Equipotential contour plotting in an electrolytic analogy tank. The Electrometer is a particularly useful instrument for electrolytic field plotting. Conventional techniques are employed, dc potential is applied, and a high resistance electrolyte is used. In addition to the usual following of preset equipotential lines, the potential of any point can be read directly.

TYPICAL CURRENT MEASUREMENTS

The Electrometer is converted quickly to a micromicroammeter by use of the Keithley Decade Shunt, Model 2008, which permits accurate measurements as low as 5×10^{-14} ampere.



Photoelectric cell current. With very high shunt resistances, small currents which represent very low levels of illumination can be measured. It is important to keep the leakage across the photocell and its connector low, for the measured current should be predominantly emission current. The G terminal should always be kept at ground potential. Mass spectrometer currents and inverse currents in semiconductors can easily be measured by the same direct method.



Ion Chamber current by accumulation of charge, or measuring total accumulated charge. Current from sources such as photoelectric cells or ion chambers can be measured by the rate of accumulation of charge on a known capacitance. Discharge C, and observe the increase of E_2 with time.

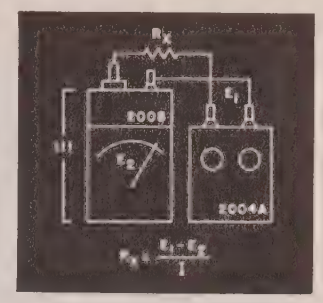
The current, derived from the relationship in the diagram, is the magnitude of a constant current or the average value of a varying current. The value of C determines the rate of rise, and should be chosen so that the time can be read accurately. A low leakage capacitor should be used. The electrometer can be removed from the circuit during the accumulation to prevent its grid current from charging the capacitor.

The total accumulated charge resulting from an instantaneous exposure of a photocell to light or an ion chamber to radiation can also be measured with this circuit. E_2, the capacitor potential, is made zero initially, and the accumulated charge is CE_2, as indicated.

It is essential that the charge originate in an infinite impedance source such as a photocell or an ion chamber.

The charge Q is a measure of the total radiation dose when an ion chamber is the current source. When a photocell is the current source, the charge is a measure of the total light falling on the cell and corresponds to photographic exposure.

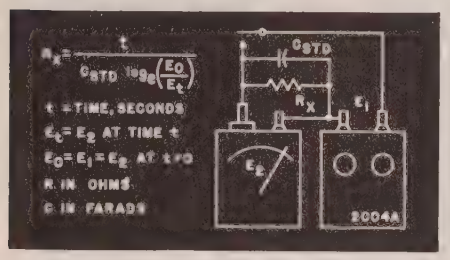
TYPICAL RESISTANCE MEASUREMENTS



The Keithley Electrometer can be used for accurate measurement of resistances up to approximately 10^{16} ohms. Here are three suggested methods:

Insulation leakage resistance. Make the connections as shown, and allow the circuit to come to equilibrium after releasing the input switch.

It should be noted that high resistances often do not follow Ohm's law, but exhibit appreciable voltage coefficients of resistance. This effect is observed by trying various values of E_1. The voltage across R_S must be kept within the manufacturer's rating, or the voltage coefficient of the standard will introduce some error.

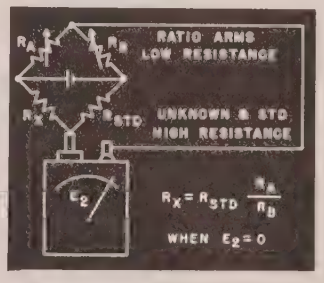


High Resistance by the Charge leakage method. High resistances may be measured with the Electrometer, a good capacitor (leakage resistance high compared with the unknown), and a stop watch. In the illustration a Keithley Regulated Voltage Supply is used as a convenient charging source. Once the capacitor is charged, the switch is released, the decay of E_2 with time is observed, and the unknown resistance is computed.

The leakage resistance of the capacitor may be determined by omitting R_X from the circuit.

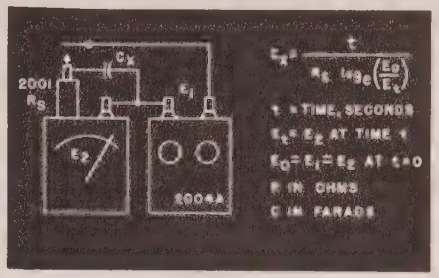
This measurement method can also be used to determine the deviation of the capacitor and leakage resistance from the ideal relationship. By plotting the decay of voltage with time on semi-log graph paper (time-linear, voltage-logarithmic), departure from a straight line indicates the presence of factors other than R and C. Such a capacitor probably cannot be used for accurate integrating over long periods of time. If C has little capacitance, correction should be made for the internal capacitance of the Electrometer, Section III. In extreme cases it may also be necessary to correct for grid current, Section III.

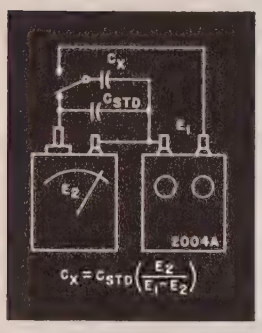
High Resistance by Wheatstone Bridge Method. Accurate measurements of high resistances can be made by using the familiar Wheatstone Bridge. The Ratio Arms, R_A and R_B, of relatively low resistance, are adjusted until the Electrometer reads zero. The voltage coefficients of the standard and the unknown can affect the balance point; this can be checked by varying the battery voltage.



TYPICAL CAPACITANCE MEASUREMENTS

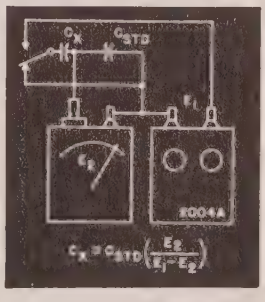
Measurement of Capacity by Charge leakage method. This uses the same circuit as measuring resistance by the charge leakage method except a Keithley Shunt is used as a standard resistance and the equation is solved by capacitance. Thus, a standard high resistance can be used to measure the capacity of a low leakage capacitor.





Measurement of capacity, parallel capacitors. Switch C_x and C_{STD} in parallel, and discharge the system. Switch C_x to E_1, charging it. Finally, switch C_x across C_{STD} and the Electrometer. The charge is conserved and the unknown capacitance is computed.

Measurement of capacity, series capacitors. Switch C_x to ground, discharging both capacitors. Switch C_x to connect E_1 across the capacitors in series. The charges will be equal on both capacitors, and the relationship under the diagram gives the unknown.



In both the series and parallel methods of measuring capacity, C_x and C_{STD} can be interchanged to increase the range of measurement.

The Keithley Regulated Voltage Supply, Model 2004A, is a convenient source for E_1 in each of the above set-ups.

VOLTAGE DIVIDERS -- MODELS 2006, 2007

Two resistive voltage dividers are made by Keithley Instruments. The Model 2007 is taller than the Model 2006 Divider illustrated; both may be used with all Keithley 200-series Electrometers.

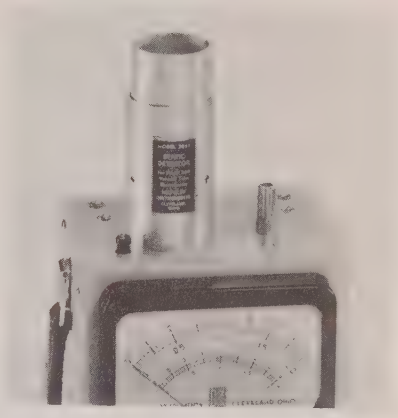
No special techniques are required in using the dividers. Each plugs over the HI terminal of the Electrometer, extending its range by the ratio indicated on the nameplate.

Principal characteristics are as follows:

MODEL	RATIO	RATIO ACCURACY	INPUT RES. OHMS	MAX. INPUT V.	VOLTAGE COEFF.	TEMP. COEFF.	RESISTOR MANUFACTURER
2006	100:1	5%	10^{12}	2000	-	-0.2%/°C	RPC
2007	1000:1	5%	10^{12}	20000	-	-0.2%/°C	RPC

RPC Resistance Products Company, Harrisburg, Pennsylvania

MODEL 2005 STATIC DETECTOR



Description. The Model 2005 Static Detector is an accessory for Keithley Electrometers which increases their usefulness in locating static charges.

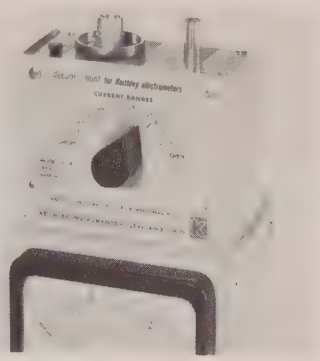
The Electrometers are extremely sensitive to static charges--so much so as to be almost useless for locating a charged object, especially in an area where other electrostatic fields are present. The Static Detector controls the sensitivity of the Electrometer and also gives a directional characteristic to the instrument. Maximum sensitivity is along the cylinder axis.

Operation The Static Detector is clipped onto the Electrometer HI terminal. The meter is then set to zero electrically by depressing the Input Switch and turning the zero knob. If the charges being investigated are of unknown polarity, as is usually the case, the meter should be set to the center zero. This zero setting must be done away from the charged object. If the meter zero is set while in the static field the meter will deflect in a direction opposite from normal when the instrument is removed from the field.

The sensitivity of the instrument is determined by the meter range and by the position of the inner tube of the Static Detector. Least sensitivity results when the meter is set on the highest voltage range and the inner tube is fully extended. Closing the tube completely will increase the sensitivity about 200 times. Switching to the most sensitive voltage range of the Electrometer will, of course, give maximum sensitivity.

Normally the instrument will be held in the operator's hands and readings will be made as outlined. If the stray fields are strong enough, a charge may be induced in the operator's body, which will cause erroneous readings. In such cases it may be necessary to run a metallic conductor from the earth to the G terminal of the Electrometer.

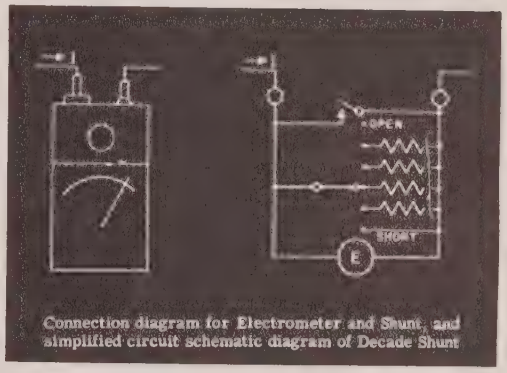
MODEL 2008 DECADE SHUNT



DESCRIPTION This shunt clips onto a Keithley Electrometer to make a very sensitive micro-microammeter. Current ranges on the panel are reciprocals of resistor values in the circuit. The current being measured is simply the Electrometer reading times the current range. Thus, 1.5 volts on the 10^{-12} range is 1.5 x 10^{-12} ampere.

Both the Short position of the selector switch, and the button on top short-circuit the input, to permit zeroing the Electrometer pointer. The Open position disconnects all resistors, permitting voltage measurements with minimum current drain.

The low terminal is connected internally to the cabinet, and should be on the low impedance side of the test circuit.



Connection diagram for Electrometer and Shunt, and simplified circuit schematic diagram of Decade Shunt

OPERATION Turn on the Electrometer, zero the pointer, and turn the Shunt switch to the right until the Electrometer needle indicates. Overlapping voltage ranges of the 200A and 210 Electrometers permit upper-scale readings of most currents.

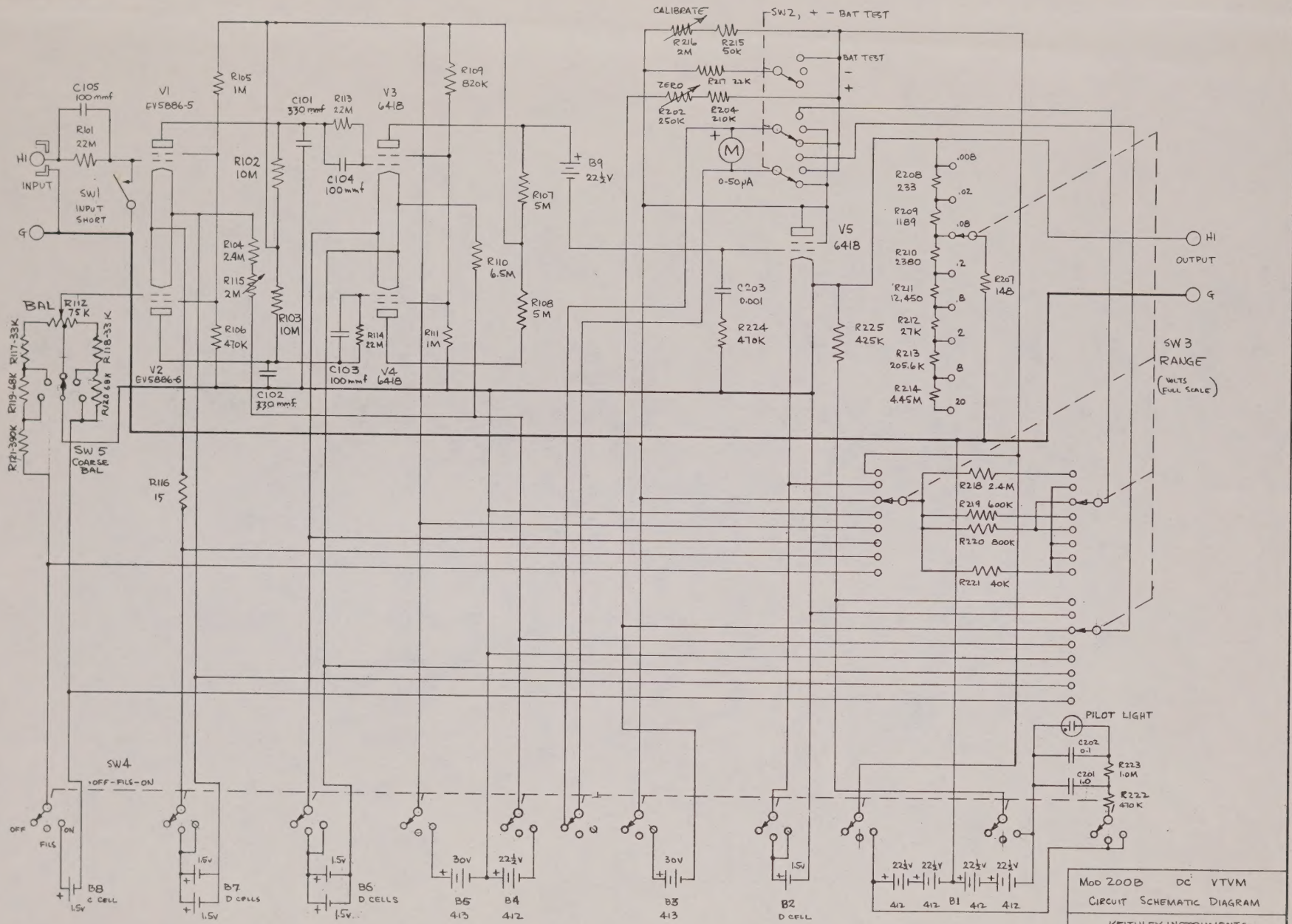
Keep test leads short, and shield high-impedance circuits to prevent disturbances from stray electrostatic and power-frequency fields.

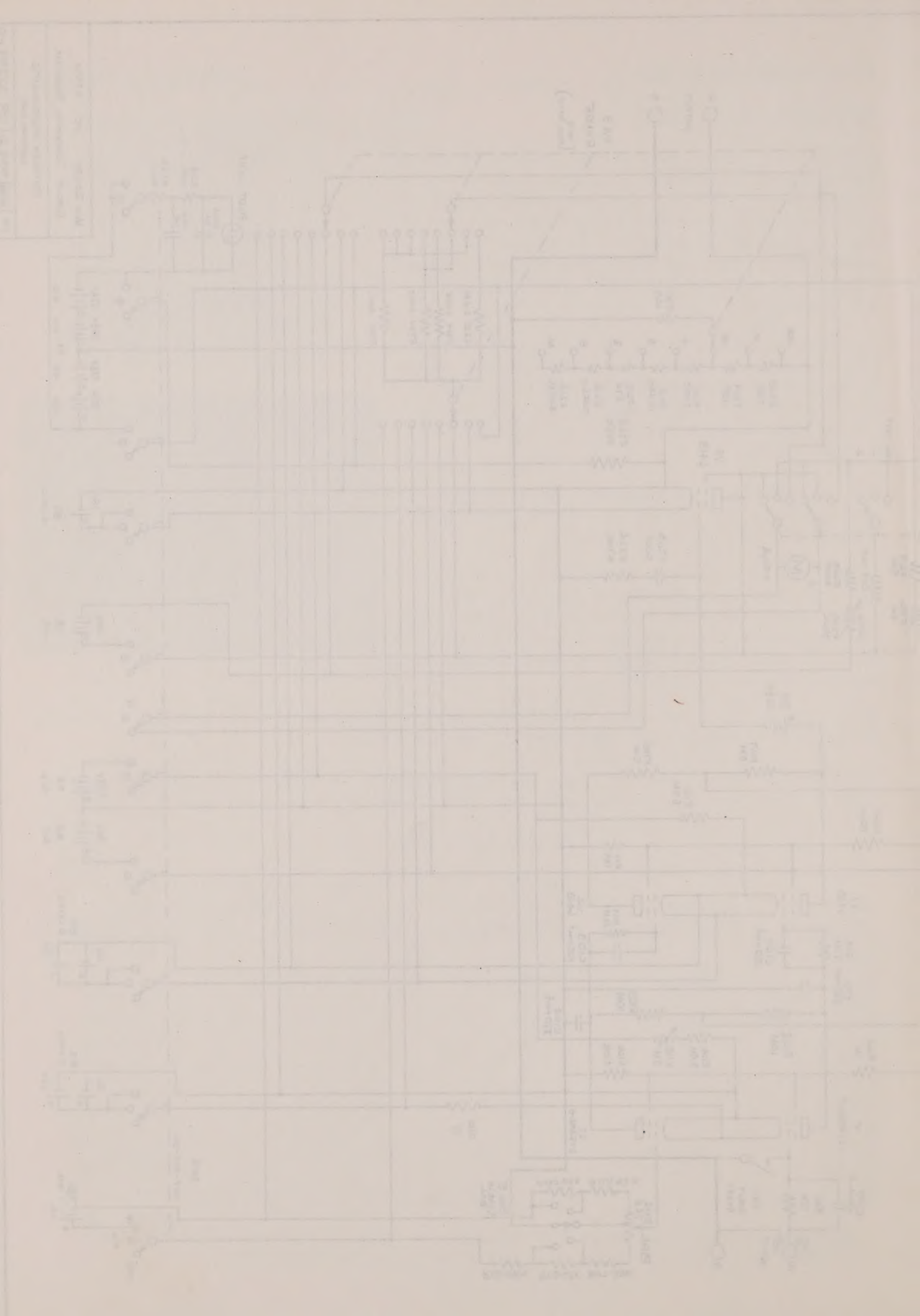
MAINTENANCE Occasionally clean the insulation at the high terminal and switch with a lint-free cloth. Do not touch the glass resistor envelopes with the hands.

RESISTOR SPECIFICATIONS

Current Range	Ohms Resistance	Nominal Resistor Tolerance	Amps Full Scale on Typical Electrometer Ranges	
			30 mv Range	0.8 v Range
Short	0			
10^{-3}	10^{3}	1%	3 x 10^{-5}	8 x 10^{-4}
10^{-4}	10^{4}	1%	3 x 10^{-6}	8 x 10^{-5}
10^{-5}	10^{5}	1%	3 x 10^{-7}	8 x 10^{-6}
10^{-6}	10^{6}	1%	3 x 10^{-8}	8 x 10^{-7}
10^{-7}	10^{7}	1%	3 x 10^{-9}	8 x 10^{-8}
10^{-8}	10^{8}	1%	3 x 10^{-10}	8 x 10^{-9}
10^{-9}	10^{9} +	2%*	3 x 10^{-11}	8 x 10^{-10}
10^{-10}	10^{10} +	2%*	3 x 10^{-12}	8 x 10^{-11}
10^{-11}	10^{11} +	2%*	3 x 10^{-13}	8 x 10^{-12}
10^{-12}	10^{12} +	2%*	-	8 x 10^{-13}
Open	-	*Listed at back of Shunt within 1%		

+ Temperature coefficient is 0.1 - 0.15% per degree; resistors are measured at 25°C. A drift of about 1/2% per year is to be expected.


CALIBRATE
SW2, + − BAT TEST
R216 2M
R215 50K
BAT TEST
R217 22K
ZERO
R202 250K
R204 210K
M
0-50μA
C105 100 mmf
R101 22M
HI
INPUT
G
SW1 INPUT SHORT
V1 EV5886-5
R105 1M
C101 330 mmf
R113 22M
V3 6418
R109 820K
R102 10M
C104 100 mmf
B9 22½V
R107 5M
R110 6.5M
R108 5M
R104 2.4M
R115 2M
R103 10M
R106 470K
C103 100 mmf
R114 22M
R111 1M
V4 6418
V2 EV5886-6
C102 330 mmf
BAL
R112 75K
R117 33K
R118 33K
R119 68K
R120 68K
R121 390K
SW 5 COARSE BAL
R116 15
V5 6418
C203 0.001
R224 470K
R225 425K
R208 233
R209 1189
R210 2380
R211 12,450
R212 27K
R213 205.6K
R214 4.45M
.008
.02
.08
.2
.8
2
8
20
R207 148
HI
OUTPUT
G
SW 3 RANGE (VOLTS FULL SCALE)
R218 2.4M
R219 600K
R220 800K
R221 40K
PILOT LIGHT
C202 0.1
C201 1.0
R223 1.0M
R222 470K
SW4
OFF-FILS-ON
OFF
FILS
ON
B8 C CELL 1.5V
B7 D CELLS 1.5V 1.5V
B6 D CELLS 1.5V 1.5V
B5 413 30V
B4 412 22½V
B3 413 30V
B2 D CELL 1.5V
B1 412 412 412 412 22½V 22½V 22½V 22½V
MOD 200B DC VTVM
CIRCUIT SCHEMATIC DIAGRAM
KEITHLEY INSTRUMENTS
CLEVELAND, OHIO
TFK 6/13/56 ISSUE 6 DR 10759-C



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